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BRACING FARM BUILDINGS



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By GEORGE W. TRAYER, *Senior Engineer, Forest Products Laboratory,¹ Branch of Research, Forest Service*, and M. C. BETTS, *Senior Architect, Bureau of Agricultural Engineering*

Modern farm buildings generally are of comparatively light frame construction. That failures are frequent is a matter of common observation. Sway-backed roofs, bulging walls, sagging floors, leaning of the whole structure, and complete collapse are all evidences that structural strength was not provided where needed.

Most failures of farm structures are due to improper foundations, insufficient or entire lack of anchorage of the frame to foundations or of the roof to the frame, or insufficient bracing of the frame.

Need of Adequate Foundations

The first requisite of any permanent structure is a durable, well-built foundation to carry the loads imposed and to provide anchorage for the superstructure. Information relating to the construction of farm building foundations may be found in Farmers' Bulletin No. 1636, *Farm Bulk Storage of Small Grains*. Figure 1 illustrates the failure of a barn due to the deterioration of the foundation. The building should be jacked up and the foundation repaired.

The sills of frame structures should be secured to the foundation with $\frac{5}{8}$ or $\frac{3}{4}$ inch bolts placed 6 to 8 feet apart if the foundations are continuous and at every support if the building rests on piers.

Principle of Bracing

A frame building consisting only of vertical and horizontal structural members might stand for a long time, provided it were not subjected to unequal pressures applied in various directions. Thorough bracing of the frame is necessary if it is to resist the stresses set up by heavy winds or unequal or moving loads.



FIGURE 1.—A farm barn with a decided "lean" caused by the failure of a part of the foundation

¹Maintained at Madison, Wis., in cooperation with the University of Wisconsin.

A brace is a piece of material used to transmit or resist weight or pressure. It is used as a tie or strut in connection with other structural members to form triangles which tend to prevent distortion of the structure.

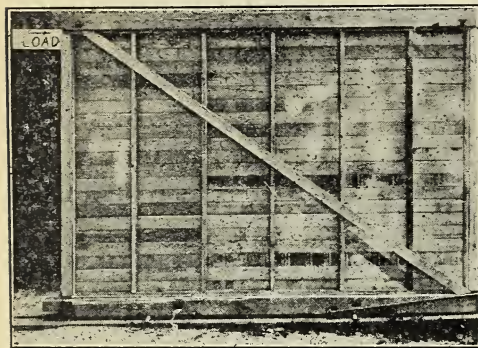


FIGURE 2.—Test panel consisting of sill and plate with studs spaced about 2 feet apart and covered with 6-inch drop siding, each board being secured with two nails at each stud. The 1 by 4 inch diagonal brace made the panel three times as rigid and strong in the plane of the wall as it was without the brace

The method of bracing will vary with the design of the particular building, but the general principle of using braces to form triangles with other structural members should be observed.

The Forest Products Laboratory has tested a number of panels of stud wall construction (fig. 2) to determine the value of diagonal bracing. Practical applications of the diagonal brace in stiffening frame buildings are shown in Figure 3.

Application of Diagonal Bracing

Buildings having walls of stud construction should be braced at each corner in both directions with a diagonal member *a* (fig. 3) extending from the plate *b* at the corner downward to the sill *c*, or from the sill *c* at the corner upward to the plate. A brace, *aa*, consisting of pieces of 2 by 4 inch material cut accurately between the studs, although not so effective as brace *a*, does not interfere with interior covering of the studs.

To prevent racking of the roof, diagonal braces *f* of 1 by 4 or 6 inch boards should be nailed to the underside of the rafters (*e*). There should be one such brace at each corner of the building extending as nearly as possible at an angle of 45° from the plate, at the junction of the side and end walls, to the ridgepole *g*, or from the end of the ridge diagonally down to the plate. Similar bracing should be pro-

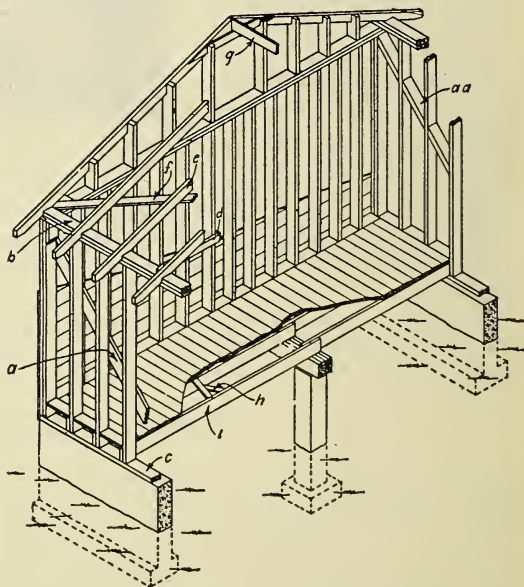


FIGURE 3.—Bracing in frame buildings to counteract the effect of stresses set up by wind and interior loads. Reference is made in the text to the several methods of bracing designated by letters

vided for the side and end walls, to the ridgepole *g*, or from the end of the ridge diagonally down to the plate. Similar bracing should be pro-

vided in all roofs except the hip type, which pitches toward the center from each wall.

Sway-backed gable roofs (fig. 4) usually are the result of a lack of crossties (fig. 3, *d*) which should be provided to prevent spreading of the rafters and consequent outward bulging of the wall plates. In small structures of this type a tie at every third rafter, or diagonal bracing (fig. 3, *f*) on the underside of the roof, is generally sufficient. Where joists are used to support a floor at the plate level they provide the necessary lateral stiffness.

The bridging, *h*, of joists *i* prevents twisting and overturning of the joists under load and makes them act together; bridging should be used wherever the joist span is more than 8 feet.

Where the length of rafter is such as to require support between the plate and ridgepole the usual construction consists of knee-braced



FIGURE 4.—Barn in which spreading of the walls has caused the ridge to sag

posts and purlins. (Fig. 5.) Knee bracing of girders and posts carrying floors or roofs greatly stiffens the construction.

The end walls of barns having self-supporting roofs, that is, without inner supports, should be braced as shown in Figure 6. Such braces, usually four in all, should be installed at the ends of the longitudinal girders which support the mow floor. Where the girders are crosswise of the barn the braces should be spiked to doubled joists.

The walls of structures used for storing certain products, such as corn or small grains, in bulk are subjected to outward pressure. Failures are of frequent occurrence because of insufficient or entire lack of ties. Methods of preventing such failures are described in Farmers' Bulletin No. 1636.

Wooden-stave silos, particularly when empty, are subject to destruction by wind unless, in addition to being well anchored to the foundation, they are guyed to the ground or to other structures.

Tobacco barns, hay sheds, and similar structures often consist of light framed trusses or cross bents (fig. 7) spaced 12 or 14 feet apart, put together on the ground and then raised into place. The exterior wall covering is generally of vertical boarding or sheet metal secured to horizontal nailing strips.

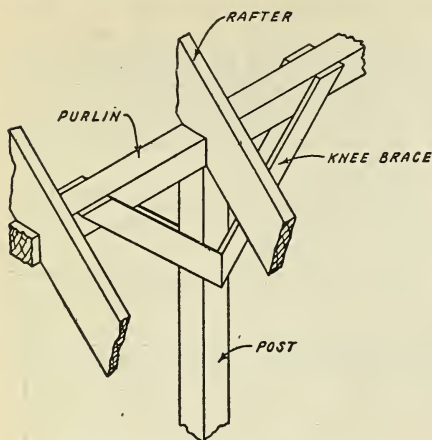


FIGURE 5.—Knee bracing of a purlin supporting roof rafters

tails of construction or the use of the building may not admit of bracing as shown, but the principles of diagonal cross bracing should be employed.

Any bracing employed to stiffen a building must be well nailed, spiked, or bolted in place. Its effectiveness is in proportion not only to the strength of the material but also to the strength of the joints.

Restoration of Distorted Structures

All buildings should be braced, as suggested in the preceding pages, when erected. Where bracing has been omitted it should be added before evidence of failure develops. However, buildings that, because of lack of bracing, have been forced out of shape by wind or undue loading may often be straightened and made safe at comparatively slight expense. Leaning structures—that is, those in which the walls, while still parallel, lean in the same direction from the vertical—may be straightened with timbers and jacks or pry poles on the outward-leaning side, or with block and tackle or steel cables and turnbuckles or windlass on the other side. In the latter case the rope or cable should be secured to the plate on the outward-leaning side and passed over the plate on the other side. When the walls have been made vertical, knee bracing should be installed between ties

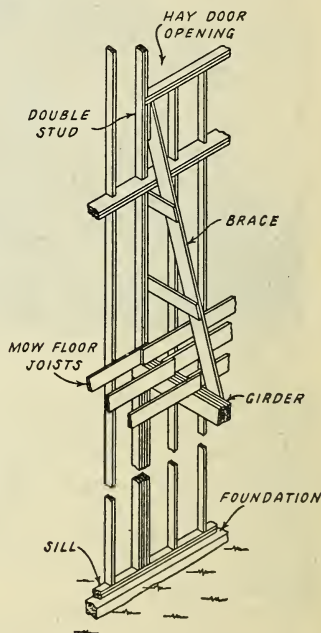


FIGURE 6.—Method of bracing the end walls of haymows in barns having roofs of the self-supporting type

or joists at the plate level and the studs. Temporary exterior struts should be employed until the bracing has been installed. They should be set up on both sides of the building and should be so arranged that, as the walls are straightened, they may be adjusted by moving the foot toward or away from the building to prevent possible collapse should there be failure of any of the equipment employed.

Sway-backed gable roofs may be straightened by raising the ridge with poles or timbers, wagon jacks, and blocks and at the same time drawing in the sides of the building. This may be done in various ways, depending upon the conditions. The walls of small structures may sometimes be drawn inward with block and tackle until they are plumb and then secured with 2 by 6 inch crossties spiked to the foot of every other rafter and to the plate. One by six inch vertical ties nailed to the rafters at the ridge and to the crossties will prevent sagging of the crossties.

As previously mentioned, the bracing under roof rafters may, in small structures, serve in lieu of crossties.

If the structure is more than 20 feet wide it would be advisable to draw the plates inward by means of $\frac{5}{8}$ or $\frac{3}{4}$ inch iron tie-rods with one or more turnbuckles, depending upon the extent to which the walls have spread. The number of rods required will depend upon the length of the building, the rods being not more than 20 feet apart.

The distance through which the wall plates must be moved in order to plumb the walls having been determined, the rods may be cut into two or more sections of proper lengths, according to the number of turnbuckles to be used, and threaded to correspond with the take-up of the turnbuckles. The outer ends of the rods should be threaded for a sufficient distance to permit of a little extra take-up with nuts should the turnbuckles prove insufficient. The outer ends of the rods should be passed through heavy timber or angle-iron cleats on the outside of the walls and fitted with large washers and nuts or burrs. The cleats should be placed immediately under the plates, overlapping them if possible, and should extend over several studs so as to prevent tearing out of the plate or individual studs. The jacks under the ridge should be raised and the turnbuckles tightened successively and a little at a time. After the walls have been straightened the tie-rods should be supported from the rafters by heavy wire or light rods.

The spreading of the walls of buildings in which the roof is supported by posts and purlins may be rectified in a similar manner. If the tie-rods interfere with the mowing of hay or other operations,

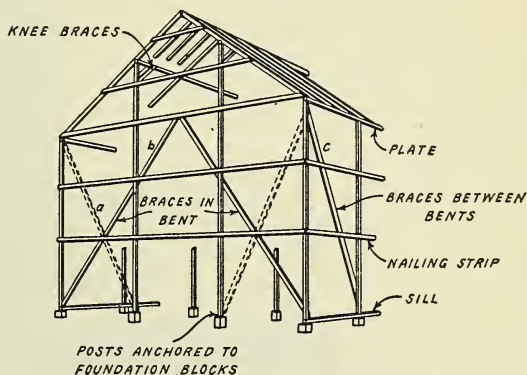


FIGURE 7.—Typical construction of sheds used for various purposes and frequently built without sufficient bracing

diagonal bracing such as *a* in Figure 7, may be installed and the rods removed. Care should be taken not to make these braces too steep.

The straightening of large buildings is sometimes expensive, but it should be done if the building is worth saving. It is much more economical to install proper bracing when the building is under construction.

